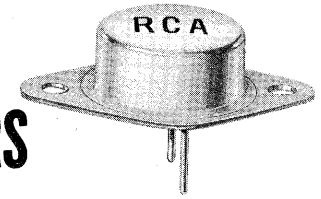
RCA POWER TRANSISTORS

2N2869/2N301
2N2870/2N301A

GERMANIUM P-N-P POWER TRANSISTORS

For AF Power-Amplifier and other Large-Signal Applications in Commercial, Industrial, and Military Equipment



Actual Size

RCA-2N2869/2N301 and RCA-2N2870/2N301A are alloy-junction power transistors of the germanium p-n-p type, designed for use in a wide variety of applications in commercial, industrial, and military equipment. These transistors are similar to and unilaterally interchangeable with types 2N301 and 2N301A respectively, but have substantially higher voltage, current, and dissipation ratings, lower saturation voltages, and linearity of beta over a wider range of collector current.

RCA-2N2869/2N301 and RCA-2N2870/2N301A can be used as direct replacements for types 2N301 and 2N301A respectively in existing equipment. Because of their higher ratings and superior characteristics, these new transistors also can provide greater power output and better performance than the 2N301 and 2N301A in new equipment designs.

RCA-2N2869/2N301 and RCA-2N2870/2N301A supersede RCA types 2N301 and 2N301A.

RCA-2N2869/2N301 and RCA-2N2870/2N301A are particularly suitable for use in class A and class B af-output-amplifier stages of automobile radio receivers and mobile communications equipment. They are also capable of providing very efficient performance in dc-to-dc and dc-to-ac power-conversion circuits.

The 2N2870/2N301A has higher collector-to-base voltage rating (-80 volts) than the 2N2869/2N301 (-60 volts), and is intended for use in applications requiring this higher voltage capability. The 2N2870/2N301A also has a lower collector-to-emitter saturation voltage (-0.3 volt typ., -0.5 volt max.) than the 2N2869/2N301 (-0.4 volt typ., -0.75 volt max.).

- High Breakdown Voltages—
  BV_{CBO} for 2N2870/2N301A = -80 volts min.
  BV_{CBO} for 2N2869/2N301 = -60 volts min.
- Low Saturation Voltages—
  $V_{CE}(sat)$ for 2N2870/2N301A = -0.3 volt typ.
  $V_{CE}(sat)$ for 2N2869/2N301 = -0.4 volt typ.
- Very Low Collector Saturation Current $I_{CBO}(sat)$ = -100 μa max. at V_{CB} = -0.5 volt—
  Assures Excellent Operating Stability for Wide Temperature Variations
- High Dissipation Capability = 30 watts max.
- High Collector Current Capability = -10 amp. max.
- High Large-Signal (DC) Beta = 90 typ.
- Excellent Beta Linearity — Essentially linear up to 10 amp. I_C
- At V_{CC} = -14.4 volts:
  (a) 5 watts output (5% THD) with 38 db power gain in single-ended class A_1 Service
  (b) 12 watts output (5% THD) with 30 db power gain in push-pull class B service
- Hermetically Sealed JEDEC TO-3 Package

Maximum Ratings, *Absolute-Maximum Values:*

	2N2869/2N301	2N2870/2N301A	
COLLECTOR-TO-BASE VOLTAGE, V_{CBO}	-60	-80 max.	volts
COLLECTOR-TO-EMITTER VOLTAGE, V_{CEO}	-50	-50 max.	volts
EMITTER-TO-BASE VOLTAGE, V_{EBO}	-10	-10 max.	volts
COLLECTOR CURRENT, I_C	-10	-10 max.	amp
EMITTER CURRENT, I_E	+10	+10 max.	amp
BASE CURRENT, I_B	-3	-3 max.	amp

* Measured at center of seating surface.

TRANSISTOR DISSIPATION:			
At Mounting-Flange Temperatures*—			
Up to +55° C	30	30 max.	watts
Above +55° C	See *Fig. 1*		
TEMPERATURE RANGE:			
Storage and Operating (Junction)	-65 to +100		°C
PIN TEMPERATURE (During Soldering):			
At distance of not less than 1/32" from seating surface for 10 seconds max.	255	255	°C

2N2869/2N301, 2N2870/2N301A
5-63 Printed in U.S.A.
Supersedes issue dated 5-58

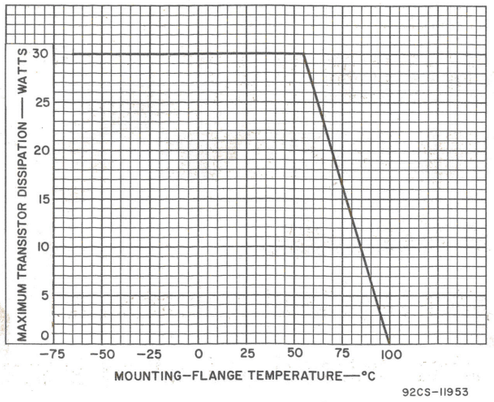


Fig.1 - Rating Chart for Types 2N2869/2N301 and 2N2870/2N301A

Electrical Characteristics, *at a Mounting-Flange Temperature, T_{MF}*, of 25° C*

Characteristics	Symbols	TEST CONDITIONS: DC Collector-to-Base Voltage V_{CB}	DC Collector-to-Emitter Voltage V_{CE}	DC Collector Current I_C	DC Emitter Current I_E	DC Base Current I_B	LIMITS: Type 2N2869/2N301 Min.	Typ.	Max.	Type 2N2870/2N301A Min.	Typ.	Max.	Units
		volts	volts	amp	ma	amp							
Collector-to-Base Breakdown Voltage	BV_{CBO}			-0.0005	0		-60	-	-	-80	-	-	volts
Collector-to-Emitter Breakdown Voltage	BV_{CEO}			-0.6		0	-50	-	-	-50	-	-	volts
Emitter-to-Base Breakdown Voltage	BV_{EBO}			0	-2		-10	-	-	-10	-	-	volts
Collector-Cutoff Current	I_{CBO}	-30			0		-	-	-0.5	-	-	-0.5	ma
Saturation Collector-Cutoff Current	$I_{CBO}(sat)$	-0.5			0		-	-	-0.1	-	-	-0.1	ma
DC Forward-Current Transfer Ratio	h_{FE}		-2	-1			50	90	165	50	90	165	
Base-to-Emitter Voltage	V_{BE}		-2	-1			-	-0.3	-0.5	-	-0.3	-0.5	volt
Collector-to-Emitter Saturation Voltage	$V_{CE}(sat)$			-10		-1	-	-0.4	-0.75	-	-0.3	-0.5	volt
Gain-Bandwidth Product	f_T		-2	-1			200	450	-	200	450	-	Kc

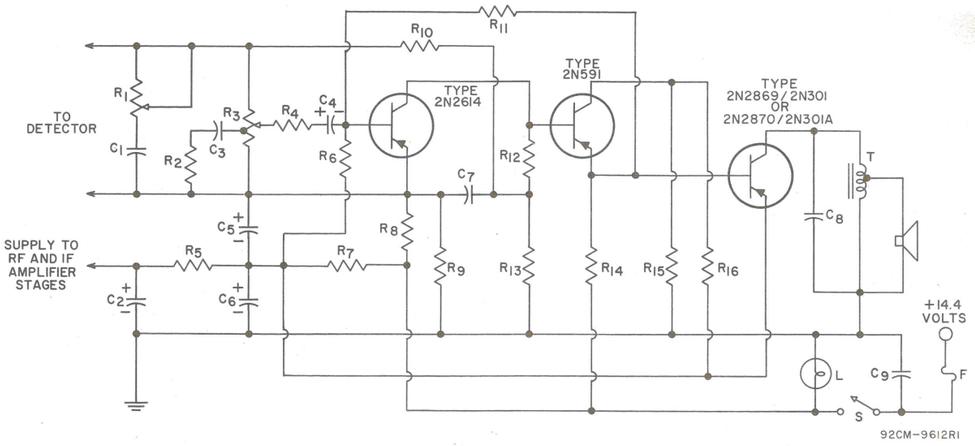
* Measured at center of seating surface.

Typical Operation for Types 2N2869/2N301 and 2N2870/2N301A in the Class A_1 Audio Power-Amplifier Circuit of Fig.2:

At Mounting-Flange Temperature of 80° C and Signal Frequency of 400 cps

DC Supply Voltage	-14.4	volts
DC Collector-to-Emitter Voltage	-12.2	volts
DC Collector Current:		
Zero-Signal	-0.9	amp
DC Base-to-Emitter Voltage	-0.35	volt
Signal-Source Impedance	10	ohms
Load Impedance	15	ohms
Power Gain●	38	db
Max.-Signal Power Output●	5	watts
Circuit Efficiency (At Power Output of 5 watts)●	45	%
Total Harmonic Distortion (At Power Output of 5 watts)	5% max.	
Collector Dissipation (Zero Signal)	11	watts

● Measured at the primary of the output transformer.



C_1 : 0.01 μf, 200 v, paper
C_2 : 400 μf, 16 v, electrolytic
C_3 : 0.22 μf, 200 v, paper
C_4 : 5 μf, 15 v, electrolytic
C_5 : 750 μf, 3 v, electrolytic
C_6 : 850 μf, 16 v, electrolytic
C_7 : 1 μf, 3 v, ceramic
C_8 : 0.047 μf, 200 v, paper
C_9 : Spark plate
R_1 : Tone control, 10,000 ohms
R_2 R_4: 680 ohms, 0.5 watt
R_3 : Volume control, 7500 ohms tapped at 6000 ohms.
R_5 : 68 ohms, 0.5 watt
R_6 : 27000 ohms, 0.5 watt
R_7 : 0.47 ohm, 0.5 watt
R_8 R_{11}: 33 ohms, 0.5 watt
R_9 : 3.9 ohms, 0.5 watt
R_{10}: 100 ohms, 0.5 watt
R_{12}: 1800 ohms, 0.5 watt
R_{13}: 1000 ohms, 0.5 watt
R_{14} R_{16}: 82 ohms, 0.5 watt
R_{15}: 120 ohms, 1 watt
T: Autotransformer, primary impedance = 20 ohms, secondary impedance = 4 ohms

Fig.2 - AF-Amplifier Section of Typical Automobile Receiver.

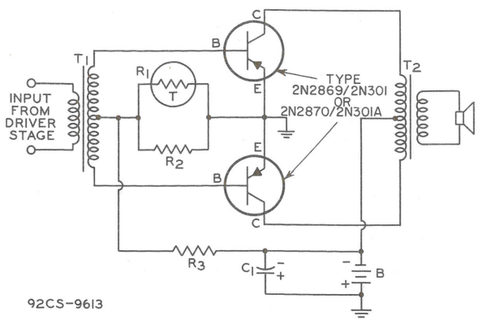
Typical Operation for Types 2N2869/2N301 and 2N2870/2N301A in the Class B Push-Pull Audio Power-Amplifier Circuit of Fig.3:

At Mounting-Flange Temperature of 80° C and Signal Frequency of 400 cps

Unless otherwise specified, values are for two transistors

DC Supply Voltage	-14.4	volts
Zero-Signal DC Collector Current□	-0.05	amp
Zero-Signal DC Base-to-Emitter Voltage	-0.13	volt
Peak Collector Current□	-2	amp
Max.-Signal DC Collector Current□	-0.64	amp
Signal-Source Impedance (per base)	10	ohms
Load Impedance (Per collector)	6	ohms
Power Gain●	30	db
Max.-Signal Power Output●	12	watts
Total Harmonic Distortion (At Power Output of 12 watts)	5% max.	
Circuit Efficiency (At Power Output of 12 watts)●	67	%
Collector Dissipation (Per Transistor at Power Output of 12 watts)	3	watts

● Measured at the primary of the output transformer.
□ Per transistor.



B : 14.4-volt supply

C_1: 1000 μf, electrolytic, 25 volts

R_1: Thermistor, 28.25 ohms at 0° C, 10 ohms at 25° C, 4.06 ohms at 50° C

R_2: 5.6 ohms, 0.5 watt

R_3: 270 ohms, 1 watt

T_1: Driver Transformer: Primary Impedance determined by large-signal considerations of the driver unit. Secondary Impedance = 40 ohms center tapped.

T_2: Output Transformer: Primary Impedance = 24 ohms center tapped, Secondary Impedance = voice-coil Impedance.

Fig.3 - Class B Push-Pull AF Power-Amplifier Circuit Utilizing Types 2N2869/2N301 and 2N2870/2N301A.

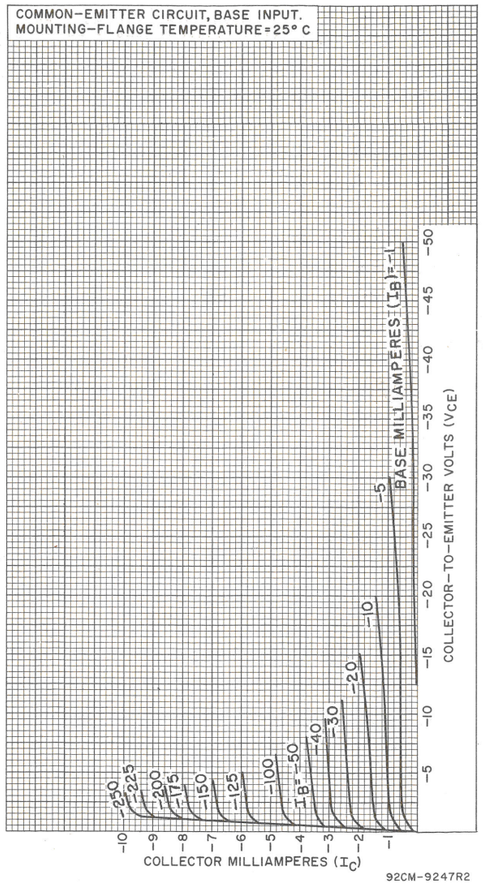


Fig.4 - Typical Collector Characteristics for Types 2N2869/2N301 and 2N2870/2N301A.

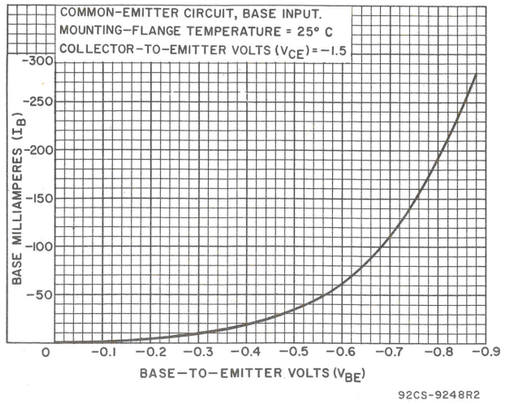


Fig.5 - Typical Input Characteristic for Types 2N2869/2N301 and 2N2870/2N301A

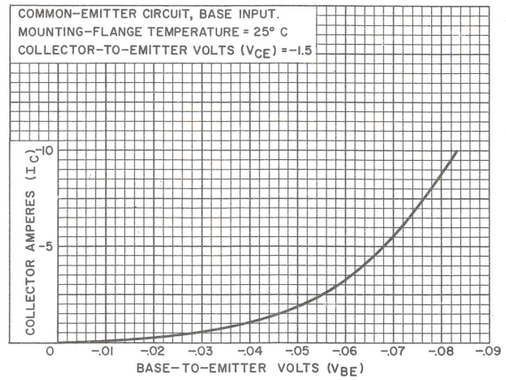


Fig.6 - Typical Transfer Characteristic for Types 2N2869/2N301 and 2N2870/2N301A

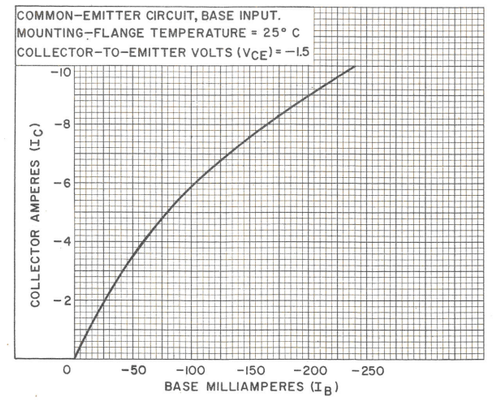


Fig.7 - Typical Current-Transfer Characteristic for Types 2N2869/2N301 and 2N2870/2N301A

OPERATING CONSIDERATIONS

The *maximum ratings* in the tabulated data are established in accordance with the following definition of the *Absolute-Maximum Rating System* for rating electron devices.

Absolute-Maximum ratings are limiting values of operating and environmental conditions applicable to any electron device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

The device manufacturer chooses these values to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environment variations, and the effects of changes in operating conditions due to variations in device characteristics.

The equipment manufacturer should design so that initially and throughout life no absolute-maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply-voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in device characteristics.

In class A service, to insure stable operation and low distortion, it will be necessary to provide some degeneration in the emitter circuit. This degeneration may be accomplished by using an unbypassed resistor in the emitter circuit as shown in Fig.2.

In class B service, if the 2N2869/2N301 or 2N2870/2N301A is operated near its maximum collector voltage rating, it is important that circuit arrangements be made to prevent thermal runaway. A convenient method is to reduce the base-to-emitter forward voltage by an amount equal to approximately 0.002 volt for each degree centigrade that the mounting-flange temperature is above 25° C.

In the design of circuits using the RCA-2N2869/2N301 and 2N2870/2N301A it is extremely important to assure that the maximum junction-temperature rating of 100° C is not exceeded. This consideration is especially important in af-amplifier and other applications involving complex signal waveforms and other factors capable of producing high peak values of dissipation, such as

(a) oscillation or "ringing" due to excessive or improperly neutralized feedback
(b) phase shifts due to circuit capacitances and/or reactive loads
(c) variations in load impedance
(d) overdriving of transistors
(e) high line voltage

Because of the short thermal time constant of the RCA-2N2869/2N301 and 2N2870/2N301A (approximately 15 milliseconds), the rise in junction temperature produced when so-called "instantaneous" peak values of dissipation are sustained for longer than 15 milliseconds may be as great as 1.5° C per watt. The circuit designer, therefore, must select operating conditions such that no possible combination of the factors listed above, or any other operating condition will cause the junction temperature to rise above 100° C.

Because the metal shells of these transistors operate at the collector voltage, consideration should be given to the possibility of shock hazard if the shells are to operate at a voltage appreciably above or below ground potential. In such cases, suitable precautionary measures should be taken.

The 2N2869/2N301 and 2N2870/2N301A should not be connected into or disconnected from circuits with the power on because high transient currents may cause permanent damage to the transistors.

These transistors can be installed in commercially available sockets. Electrical connection to the base and emitter pins may also be made by soldering directly to these pins. Such connections may be soldered to the pins close to the pin seals provided care is taken to conduct excessive heat away from the seals. Otherwise the heat of the soldering operation will crack the pin seals and damage the transistor.

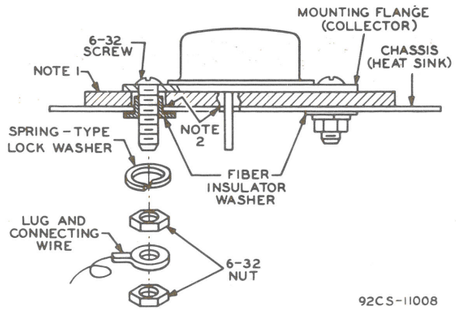
It is essential that the mounting flange which serves as the collector terminal be securely fastened to a heat sink, which may be the equipment chassis. UNDER NO CIRCUMSTANCES, HOWEVER, SHOULD THE MOUNTING FLANGE BE SOLDERED TO THE HEAT SINK OR CHASSIS BECAUSE THE HEAT OF THE SOLDERING OPERATION WILL PERMANENTLY DAMAGE THE TRANSISTOR.

The mounting-flange temperature of the 2N2869/2N301 or 2N2870/2N301A will be higher than the ambient (free-air) temperature by an amount which depends on the heat sink used. The heat sink must have sufficient thermal capacity to assure that the heat dissipated in the heat sink itself does not raise the transistor-mounting-flange temperature above the design value.

Depending on the application, the heat sink or chassis may be connected to either the positive or negative terminal of the voltage supply.

In applications where the chassis is connected to the positive terminal of the voltage supply, it will be necessary to use an anodized aluminum washer having high thermal conductivity, or a 0.002" thick mica insulator between the mounting flange and the chassis. If an aluminum washer is used, it should be drilled or punched to provide the two mounting holes and the clearance holes for the emitter and base pins. The burrs should then be removed from the washer and the washer finally anodized. To insure that the anodized insulating layer is not destroyed during mounting, it will also be necessary to remove the burrs from the holes in the chassis. Furthermore, to prevent a short circuit between the mounting bolts and the chassis, it is important that a fibre washer be used between each bolt and the chassis as shown in Fig.8.

An insulated mounting arrangement such as that described in the preceding paragraph and shown in Fig.8 is also necessary when Type 2N2869/2N301 or 2N2870/2N301A transistors are used in class B push-pull af-amplifier stages of the type shown in Fig.3. In such stages the mounting flanges of the two transistors must be insulated from the chassis or heat sink and from each other to avoid short-circuiting the primary winding of the output transformer.

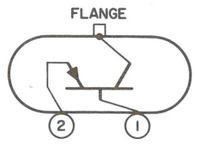


NOTE 1: 0.002" MICA INSULATOR OR ANODIZED ALUMINUM INSULATOR (DRILLED OR PUNCHED WITH BURRS REMOVED).

NOTE 2: REMOVE BURRS FROM CHASSIS HOLES.

Fig.8 - Suggested Mounting Arrangement for Types 2N2869/2N301 and 2N2870/2N301A.

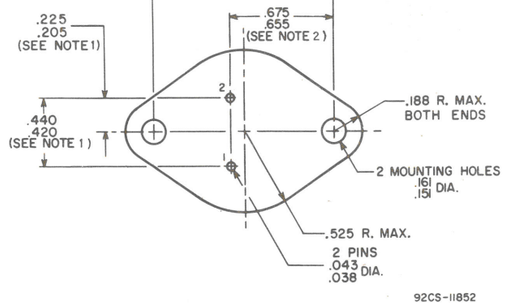
TERMINAL CONNECTIONS



Pin 1 – Base
Pin 2 – Emitter
Mounting Flange – Collector, Case

DIMENSIONAL OUTLINE For Types 2N2869/2N301 and 2N2870/2N301A

JEDEC No. TO-3



ALL DIMENSIONS IN INCHES.

For RCA-2N2869/2N301 and 2N2870/2N301A

Mounting-Flange Thickness (A) = 0.050" max.

Pin Length (B) = 0.440" min. / 0.480" max.

NOTE 1: THESE DIMENSIONS SHOULD BE MEASURED AT POINTS .050" (1.270MM) TO .055" (1.397MM) BELOW SEATING PLANE. WHEN GAGE IS NOT USED, MEASUREMENT WILL BE MADE AT SEATING PLANE.

NOTE 2: TWO LEADS.

Information furnished by RCA is believed to be accurate and reliable. However, no responsibility is assumed by RCA for its use; nor for any infringements of patents or other rights of third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of RCA.

2N2869/2N301 2N2870/2N301A

GERMANIUM P-N-P POWER TRANSISTORS

RADIO CORPORATION OF AMERICA
SEMICONDUCTOR AND MATERIALS DIVISION SOMERVILLE, N. J.

Trademark(s) ® Registered
Marca(s) Registrada(s)